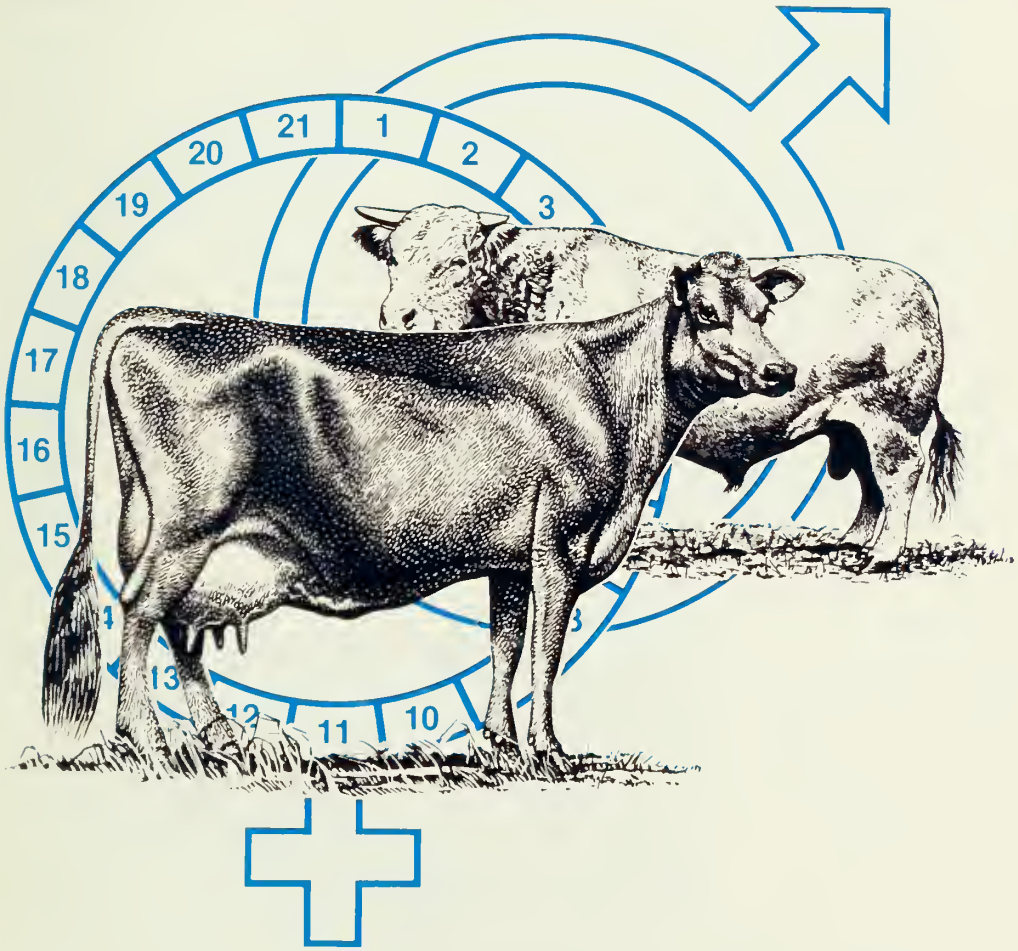
The Bovine Estrous Cycle

Dynamics and Control



University of Illinois at Urbana-Champaign
College of Agriculture, Cooperative Extension Service
Circular 1205

Contents

This circular was prepared by T.R. Troxel, Research Assistant in Animal Science, University of Illinois at Urbana-Champaign, and by D.J. Kesler, Associate Professor of Animal Science, University of Illinois at Urbana-Champaign.

Many cattle producers are interested in controlling the bovine reproductive cycle because they wish to take advantage of artificial insemination. In recent years new estrus control programs have been developed, and the producer who uses any one of them wisely will almost surely improve his breeding program. The producer who uses an estrus control program without understanding how it works, however, may be disappointed by his results. This publication explains the bovine estrous cycle and describes how it may be controlled. It also discusses how to recognize the signs of estrus and provides basic information on common reproductive problems and the major reproductive organs of the cow.

The Estrous Cycle

The estrous cycle is the series of events that occur from one period of estrus to the next. Estrus, which is commonly referred to as day zero in the cycle, is the period during which the cow is sexually receptive to the bull. If the cow does not become pregnant, estrus will reoccur about every 21 days.

The estrous cycle may be divided into two major phases. The first, or follicular phase, is characterized by the development of the *follicle,* which is the structure on the ovary that contains the egg. This phase climaxes when the egg is released and allowed to travel down the oviduct for union with the sperm. The next phase, called the luteal phase, is characterized by the development of the *corpus luteum.* This structure, which forms from the ruptured follicle, produces progesterone, the hormone that maintains pregnancy. If the egg has been fertilized, the corpus luteum will be maintained; if the egg has not been fertilized, the corpus luteum will regress, and another follicular phase will then occur.

Figure 1. Major reproductive organs of the cow.

The actions of the reproductive organs during these phases are regulated by five major hormones: GnRH, FSH, LH, estrogen, and progesterone. GnRH (gonadotropin releasing hormone) is produced by the hypothalamus, an organ in the brain (see Figure 2). It has been given this name because it stimulates the release of the two gonadotropins: FSH (follicle stimulating hormone) and LH (luteinizing hormone). Both of these hormones are produced by the anterior pituitary (see Figure 2). The last two hormones, estrogen and progesterone, are produced by structures on the ovaries.

The Follicular Phase

The hypothalamus initiates the follicular phase by releasing GnRH into a small blood system that runs between the hypothalamus and the pituitary gland (see Figure 2). Upon reaching the anterior pituitary, GnRH stimulates it to release FSH and LH, which then travel through the blood system to the ovaries. FSH, which always appears to be elevated, initiates development of the follicles throughout the estrous cycle. LH acts in synergism with FSH to stimulate maturation of the follicles.

As a follicle develops and matures, the egg also matures, and the cells lining the follicle wall multiply until the follicle becomes a fluid-filled cavity resembling a blister (Figure 3). At this point, the cells lining the follicle wall also begin to produce estrogen. The concentrations of estrogen increase as the follicle continues to mature, and upon reaching a certain level they stimulate *behavioral estrus,* or "heat." Estrogen is also responsible for the dilation of the cervix, the synthesis and secretion of cervical mucus, and the transport of sperm (see discussion of cervix, page 14). In addition, it acts in a unique manner in the hypothalamus and the pituitary gland to

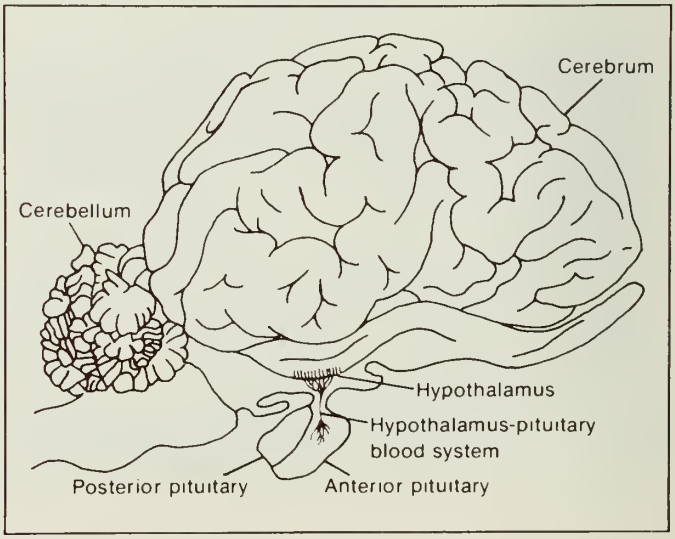


Figure 2.
Major structures of the cow brain.

Figure 3.
Ovary with developing follicles.

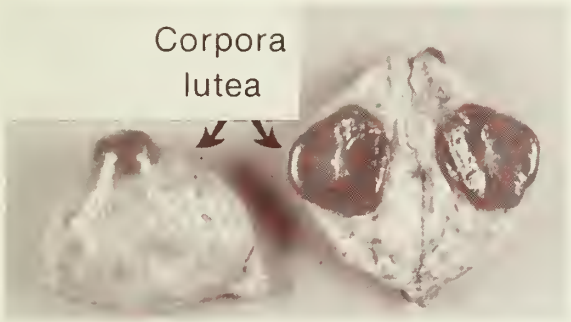


Figure 4.
Corpora lutea. The ovary on the right has been cut to show how deep the corpus luteum grows.

stimulate a massive release of LH called the *LH surge*. The LH surge, which lasts for 8 to 10 hours, stimulates the largest follicle to rupture and to release the egg (*ovulation*). This event occurs about 24 hours after the LH surge. The infundibulum then picks up the egg and rapidly transports it down the oviduct to the ampullary-isthmic junction for potential fertilization (see discussion of oviduct, page 15).

The Luteal Phase

After ovulation, estrogen levels drop rapidly, and the cells in the ruptured follicle begin to grow and divide to form a new structure called the corpus luteum (Figure 4). The corpus luteum, also called yellow body because of its yellow color, begins to produce a hormone called progesterone. If conception occurs, the corpus luteum will be maintained and will continue to produce progesterone, since progesterone appears to be required to maintain pregnancy. If conception does not occur, progesterone levels will drop and the corpus luteum will regress, usually after 16 or 17 days (Figure 5). This regression may be due to an increase in a substance, such as prostaglandin $F_2\alpha$, to destroy the corpus luteum, to the lack of a substance to maintain the corpus luteum, or to a combination of both. In any event, the decline in progesterone allows for release of LH, which, together with FSH, stimulates further development and maturation of the follicles. Another ovulation then occurs.

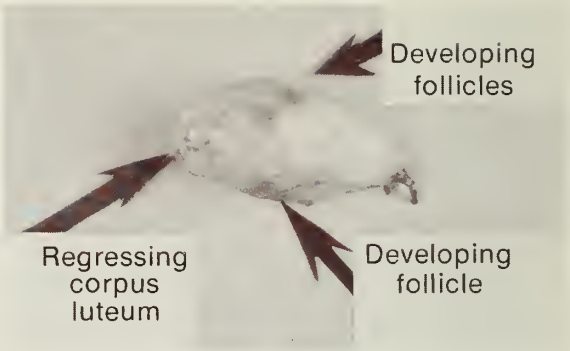


Figure 5.
Ovary showing a regressing corpus luteum and several developing ovarian follicles.

Sources and Functions of the Major Reproductive Hormones

Hormone	Source	Function
GnRH	Hypothalamus	Releases FSH and LH
FSH	Anterior pituitary	Stimulates development of ovarian follicles
Estrogen	Ovarian follicle	Stimulates behavioral estrus and the LH surge
LH	Anterior pituitary	Stimulates rupture of a follicle (ovulation)
Progesterone	Corpus luteum	Maintains pregnancy

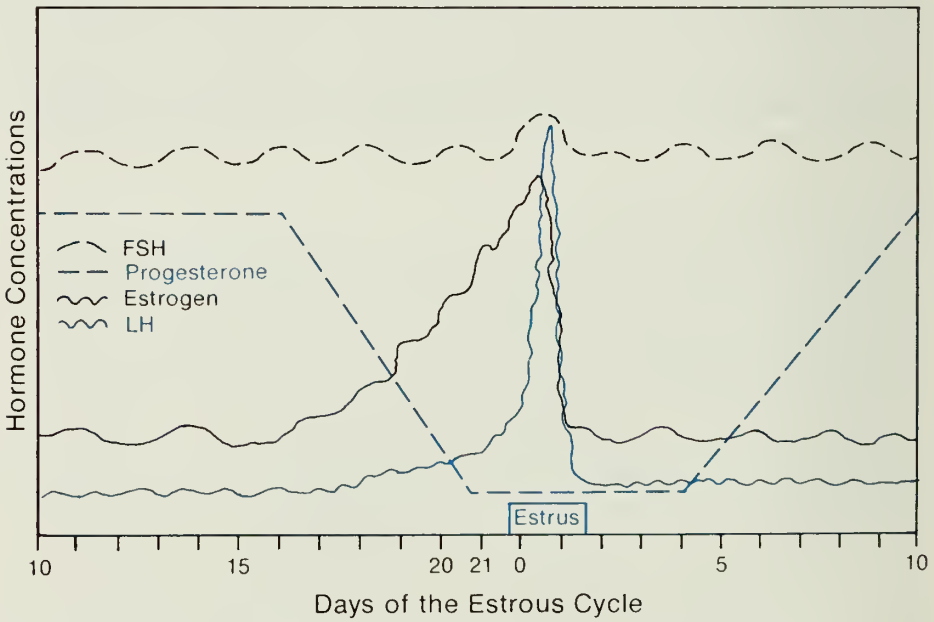


Figure 6. Hormone concentrations during the estrous cycle.

Signs of Behavioral Estrus

Behavioral estrus, often called "heat," is the period preceding ovulation during which the cow or heifer is receptive to the bull. This period normally lasts 12 to 24 hours. To use artificial insemination or to control natural mating, the producer must be able to recognize the signs of estrus. The cow will often have clear mucus on the vulva, and she may also exhibit certain behaviors: she may become unusually nervous, she may have reduced appetite and milk production, and she may butt, bellow, and walk about more than usual. She may also attempt to mount other cows; however, since this behavior is also seen in cows that are *not* in estrus, it is not a reliable indicator of estrus. The most reliable sign of estrus is that the cow will stand *to be mounted* by other cows or by a bull.

Producers should check for estrus two or more times daily. Since estrus tends to occur at night, it is best to check both in the early morning and in the late evening. Producers can also use testosterone-treated cows or surgically altered bulls to help in estrus detection (see Suggested Reading).

Estrus Synchronization

Estrus synchronization is the manipulation of the reproductive processes so that all females can be bred during a short, predefined interval with normal fertility. This control facilitates breeding in two important ways: it reduces, and in some cases eliminates, the labor of estrus detection, and it allows the producer to schedule his breeding. For example, if a herd can be induced to exhibit estrus at about the same time, the producer can arrange for a few days of intensive insemination. Although the total amount of labor involved with insemination may not be reduced, it is concentrated into a much shorter period and so does not monopolize such a large part of the producer's time. Estrus synchronization has several other advantages: it creates more uniform calf crops, it enables the producer to breed more cows to a select bull, and it reduces the breeding and calving seasons.

The success of an estrus synchronization program depends a great deal on the level of management. Since a cow will not respond satisfactorily to treatments if she is in poor body condition, the proper level of nutrition is critical, and the overall herd health must be maintained. The producer who uses estrus synchronization should also have adequate handling facilities (for example, holding pens, crowding alleys, and breeding chutes), and animals that are being treated should be handled carefully so that neither they nor their handlers undergo unnecessary stress.

Synchronization with $PGF_2\alpha$

One compound that is available for estrus synchronization is prostaglandin $F_2\alpha$, or $PGF_2\alpha$ — a lipid compound that is normally produced in the animal. $PGF_2\alpha$ is effective in synchronizing estrus by destroying the corpus luteum. If injected on days 6 through 16 of the cycle, it destroys the corpus luteum and causes estrus to occur within a few days (see Figure 7). It does not affect corpora lutea on days 1 through 5 of the estrous cycle, and it has little effect on already regressing corpora lutea (normally days 17 through 21 of the estrous cycle).

Three different programs using $PGF_2\alpha$ will be described and discussed. Which program you choose will depend on the specific requirements of your operation — on the amount of capital available, on your breeding and handling facilities, on the size of your herd, and on how much time you can spend on estrus detection. Following these programs is a brief discussion of breeding options.

Program 1

This program involves the use of two injections of $PGF_2\alpha$ spaced 11 days apart. No estrus detection is required either before or between injections, since all cows should respond to the second injection regardless of what stage they were in when the first injection was given. The following examples illustrate why two injections are needed.

1. If at the time of the first injection a cow is on day 3 of the estrous cycle, the first injection will not affect the corpus luteum. At the time of the second injection, however, the cow will be on day 14 of the estrous cycle. $PGF_2\alpha$ will then destroy the corpus luteum, and the cow will exhibit estrus in about 3 days.

2. If at the time of the first injection a cow is on day 11 of the estrous cycle, the first injection will destroy the corpus luteum, and the cow will exhibit estrus about 3 days later. At the time of the second injection, she will then be on day 8 of the new estrous cycle, the corpus luteum will again respond to $PGF_2\alpha$, and the cow will exhibit estrus in about 3 days.

3. If at the time of the first injection a cow is on day 19 of the estrous cycle, the first injection of $PGF_2\alpha$ will have little effect on the corpus luteum: the cow should exhibit estrus in about 2 days regardless of whether $PGF_2\alpha$ is administered or not. By the time of the second injection, however, she will be on day 9 of the new estrous cycle; she will therefore respond to the second injection of $PGF_2\alpha$ and will exhibit estrus about 3 days afterwards.

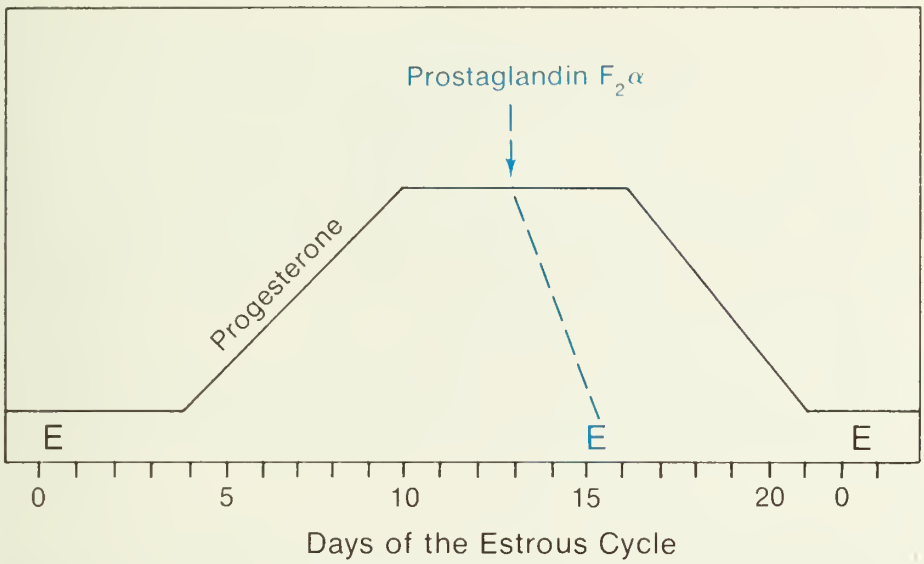


Figure 7. Prostaglandin $F_2\alpha$, or $PGF_2\alpha$, is effective on days 6 through 16 of the estrous cycle. In the example above, $PGF_2\alpha$ administered on day 13 would cause the progesterone level to drop and estrus to occur around day 15.

Advantage. More cows will come into estrus at any given time with this program than with the other two programs. At least one-half of the herd should come into estrus after the first injection of $PGF_2\alpha$; if the figure is lower, the producer should check for causes of failure such as those mentioned on pages 12 and 13.

Disadvantage. The obvious disadvantage of this program is that it involves the cost and labor of administering two injections of $PGF_2\alpha$ to all cows.

Program 2

This program requires estrus detection before the first treatment is administered. The producer watches for estrus for 5 days, breeding each cow as she comes into estrus. All cows that have not come into estrus by the 6th day are given a second injection of $PGF_2\alpha$, which will induce them to come into estrus in about 3 days. A relatively large percentage of the herd should require this injection.

Advantage. Program 2 represents the greatest savings in cost and labor associated with treatments, since only one injection is given, and not all cows will need this injection.

Disadvantage. This program requires 5 days of accurate estrus detection before the first treatment is administered.

Program 3

Program 3 is a combination of the first two programs: it requires a single injection of $PGF_2\alpha$ to all the cows, followed by a period of estrus detection, and then a second injection to those cows that have not yet come into estrus. The producer administers the first injection and then watches for estrus for 7 days, breeding each cow as she comes into estrus. All cows that have not come into estrus by the 8th day are given another injection of $PGF_2\alpha$, which will induce them to come into estrus in about 3 days. Only a small percentage of the herd should require the second injection.

Advantage. Program 3 does not require as many injections as program 1, since only a small percentage of the herd should require the second injection.

Disadvantage. This program requires 7 days of accurate estrus detection after the first injection of $PGF_2\alpha$.

Breeding $PGF_2\alpha$-Synchronized Cows

Option 1. Carefully check for estrus for a period of time following the last injection of $PGF_2\alpha$. Although most cows will exhibit estrus 2 to 4 days after this injection, some cows may exhibit estrus outside that range. If cows have not been detected in estrus by 4 days, they may still be bred at 96 hours after this injection. If you choose to use estrus detection as a breeding method, you should probably synchronize small groups of cows, since estrus detection is difficult in large groups of synchronized cows.

Option 2. Breed all cows twice: once at 72 hours and once at 96 hours after the last injection.

Option 3. Breed all cows once: at 72 to 80 hours after the last injection.

The table on page 11 shows the results of several studies of these three breeding methods. These results should not be taken as conclusive evidence that one system is more efficient than another. Every herd is different, and the same herd will often respond differently from year to year. The figures do show, however, that breeding with the three methods described does not ensure higher conception rates than breeding without estrus synchronization. In other words, *estrus synchronization does not increase any one cow's ability to conceive.* This point is made only to emphasize that you must pick your breeding method carefully, or the money and labor you have invested in estrus synchronization may be wasted.

Synchronized cows can be bred either by artificial insemination or by natural service. If you use artificial insemination, you will need an adequate supply of high-quality semen and a qualified inseminator

Conception Rates from Breeding with and without $PGF_{2\alpha}$ Synchronization

Breeding options with $PGF_{2\alpha}$			Without $PGF_{2\alpha}$	
Once: at estrus	Twice: at 72 and 96 hours	Once: at 72 to 80 hours	Once: at estrus	Source[a]
	(conception rate, percent)			
40	—[b]	—	54	1
52	56	—	53	2
40	39	33	41	3
—	57	14	50	4
59	—	62	62	5
73	—	—	69	6

[a]These sources are listed on page 15.
[b]Not tested.

who can inseminate many cows in a short period of time. If you use natural service, use one bull for every 20 synchronized cows.

Synchronization with Synchro-Mate B

Synchro-Mate B has been shown to synchronize estrus not only in cows and heifers that are exhibiting estrous cycles, but also in anestrous females (see discussion of anestrus, page 12). The Synchro-Mate B procedure involves placing a norgestomet implant in the ear for 9 days and injecting 3 milligrams of norgestomet and 5 milligrams of estradiol valerate at the time of the implant insertion. Cows or heifers can be bred at estrus for 2 to 3 days after the implant is removed, or by a predetermined breeding 48 to 52 hours after implant removal.

The Synchro-Mate B treatment suppresses estrus and ovulation *after* the corpus luteum has regressed. If the Synchro-Mate B is administered during the luteal phase of the cycle, the corpus luteum should regress on days 16 or 17 as normal, but the release of norgestomet from the ear implant will suppress estrus and ovulation until the ear implant is removed. If the Synchro-Mate B is administered shortly after ovulation (when the corpus luteum is developing), the injection of norgestomet and estradiol valerate appears to cause corpus luteum regression; once again, the ear implant will suppress estrus and ovulation until it is removed.

The table on page 12 shows the results of several studies using two breeding methods for cows synchronized with Synchro-Mate B. Note that removing calves for the 48 hours between implant removal and breeding appears to improve first-service conception rates.

Conception Rates from Breeding with and without Synchro-Mate B Synchronization

With Synchro-Mate B			Without Synchro-Mate B	
Once: at estrus	Once: 48 to 52 hours (without calf removal)[a]	Once: 48 to 52 hours (with calf removal)[a]	Once: at estrus	Source[b]
		(conception rate, percent)		
33	—[c]	—	54	7
63	—	—	66	7
56	—	—	60	7
38	—	—	63	7
45	—	—	45	7
39	35	—	34	8
—	31	—	44	8
—	32	46	—	9
—	39	51	12	10

[a]Short-term calf removal (from implant removal to breeding).
[b]These sources are listed on page 15.
[c]Not tested.

Common Reproductive Problems

The reproductive process is a complex series of events; if one event does not occur at the proper time, pregnancy may not result. Many factors can interrupt the reproductive cycle and cause either infertility or sterility, a few of which are discussed here.

Anestrus. Anestrus is any period during which cows are not experiencing estrous cycles. The most common cause of anestrus is pregnancy; qualified individuals can determine whether a cow is pregnant by examining the reproductive tract. Cattle are also anestrous during the postpartum period, which is the period immediately following calving, or parturition (see Figure 8). In beef cows that are suckling calves, this period varies, but may last as long as 60 to 100 days. In milked dairy cows, it generally lasts 20 to 30 days.

The first postpartum estrus is often difficult to detect. Since it is often shorter and milder than normal, it can easily pass unnoticed; thus the interval between calving and first estrus may actually be shorter than many producers observe. The first postpartum estrus may also be delayed by any of several factors — by the frequency of suckling or milking, by poor nutrition, by high milk production, and by problems associated with calving.

Figure 8.
Postpartum anestrous ovary.

Ovarian cysts. Ovarian cysts are structures that develop from follicles that fail to ovulate. They occur in about 5 to 15 percent of dairy cows but seldom occur in heifers and beef cows. The cysts, which can be detected by rectal palpation, are usually 2.5 to 4.0 centimeters in diameter, but may be much larger. Some cows with ovarian cysts exhibit intense sexual behavior, or nymphomania, and some cows may also develop some male characteristics. Most cows with ovarian cysts, however, are anestrous. Estrous cycles can be reestablished for about 80 percent of cows in this condition by treating them with 100 micrograms of GnRH. Administering 100 micrograms of GnRH to dairy cows two weeks postpartum will reduce the incidence of ovarian cysts. It is important to keep in mind, however, that the tendency to develop ovarian cysts is probably heritable.

Retained placenta. Cows normally expel the placenta, commonly called the "afterbirth," within 8 hours after calving. In some cases, however, the placenta may be retained — for example, when a cow gives birth to twin calves. You should usually wait two or three days before attempting to remove the placenta; if it is firmly attached, you should not attempt to remove it but should seek advice from experienced personnel. Experienced personnel should also be consulted if any other unusual problems occur.

Uterine prolapse. In uterine prolapse, part of the reproductive tract turns inside out and protrudes from the vulva. Uterine prolapse usually occurs at or shortly after calving. If you are not familiar with the treatment for this condition, you should consult a veterinarian immediately. The tendency to have uterine prolapse is heritable.

Reproductive diseases. Many reproductive diseases can affect fertility, among them vibriosis, brucellosis, leptospirosis, bovine viral diarrhea (BVD), infectious bovine rhinotracheitis (IBR, red nose), and uterine infections. Consult a veterinarian for prevention and control of these diseases. Many can be prevented by vaccination programs.

Major Reproductive Organs

Vulva. The vulva consists of two labia, or lips, that lie one on each side of the opening to the reproductive and urinary systems. The vulva serves as the entrance to the internal organs and also allows for passage of urine during urination.

Vestibule. The vestibule is the general passageway to the urinary and reproductive tracts. It extends inward from the vulva for about 10 centimeters (4 inches) to where the urethra opens into its ventral surface from the bladder. The clitoris, which has the same embryonic origin as the penis, lies on the base of the vestibule.

Vagina. The vagina is the tube that lies between the vestibule and the cervix. The bull deposits sperm in the vagina during copulation. The vagina is normally about 30 centimeters (12 inches) long.

Cervix. The cervix is the organ that separates the vagina from the uterus. It is composed primarily of connective tissue with longitudinal folds, or annular rings. The cervix's primary function is to prevent unwanted organisms and substances from entering the uterus. During estrus, however, it dilates and produces large amounts of mucus, the composition of which allows sperm to penetrate to the uterus. The cervix is usually about 8 centimeters (3 inches) long, but its size may vary with age and breed: for example, a heifer usually has a smaller cervix than a mature cow.

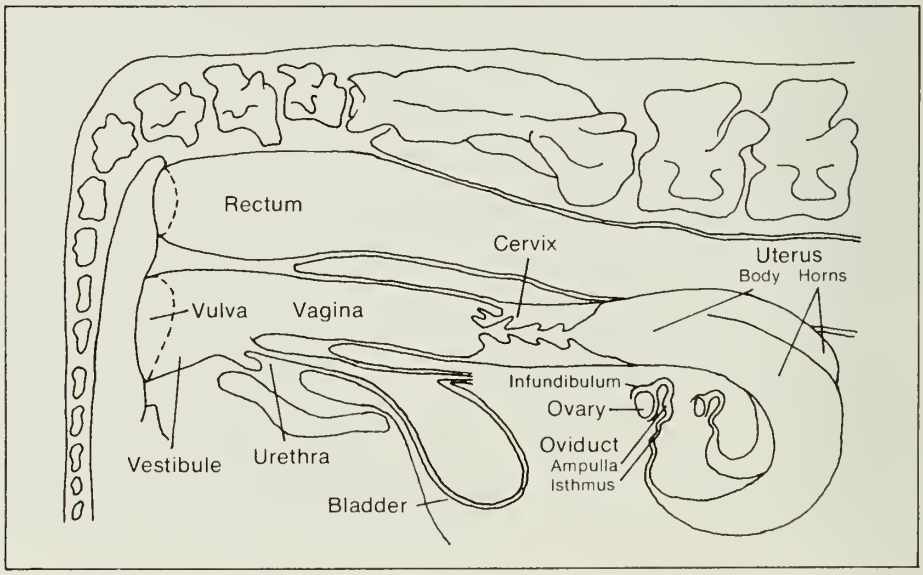


Figure 9. Major reproductive organs of the cow.

Uterus. The uterus is the organ that contains the fetus during pregnancy. It consists of a body and two horns: the body lies on the floor of the pelvis, and the horns coil downward. The uterus has two layers: a muscular inner layer, and a mucosal lining. From the mucosal lining protrude about 70 to 120 structures called caruncles that allow for attachment by the fetal membranes during pregnancy.

Oviducts. The oviducts are the two small tubes that extend from the uterine horns to the ovaries. At the ovarian end, each oviduct expands into an infundibulum, a funnellike structure that partially surrounds the ovary and receives the ovulated oocyte, or egg. Fertilization normally occurs at a point called the ampullary-isthmic junction, which is the junction of the ampulla and isthmus of the oviduct.

Ovaries. The ovaries are the oval or almond-shaped organs at the ends of the oviducts that release eggs and secrete hormones. Each ovary consists of an inner segment and an outer segment. The inner segment is composed of blood vessels, nerves, and connective tissue; the outer segment is the site of the primordial follicles, which are the oocytes (immature eggs) surrounded by a layer of cells.

Suggested Reading

The Brass Tacks of Animal Health by J. Blakely and D. D. King. Doane Agricultural Service, Inc., St. Louis, Mo. 1978. Pages 106-115.

Animal Agriculture by H. H. Cole and W. N. Garrett. 2nd ed. W. H. Freeman and Co., San Francisco. 1980. Chapters 18 and 19.

Reproduction in Farm Animals by E. S. E. Hafez. 4th ed. Lea and Febiger, Philadelphia. 1980.

Fertility and Sterility by H. D. Hafs and L. J. Boyd. Hoard's Dairyman, Fort Atkinson, Wis. 1973.

"Detection of Estrus with Testosterone-treated Cows" by D. J. Kesler and T. R. Troxel. Pages 49-50 in *1981 Beef Cattle Day*. Agricultural Experiment Station, University of Illinois at Urbana-Champaign.

Sources of data for tables on pages 11 and 12:

1 King, G. J. 1974. *Theriogenology* 1:123.
2 Lauderdale, J. W., et al. 1974. *Journal of Animal Science* 38:964.
3 Beverly, J. B. 1978. *The Outlook for Estrus Synchronization*. Proceedings, 12th Conference on Artificial Insemination of Beef Cattle. National Association of Animal Breeders (NAAB), Columbia, Mo.
4 Burfening, P. J. 1978. *Journal of Animal Science* 47:999.
5 Moody, E. L., and J. W. Lauderdale. 1977. *Journal of Animal Science* 45 (Suppl. 1) :189.
6 Donaldson, L. E. 1977. *Australian Veterinarian Journal* 53:72.
7 Spitzer, J. C., et al. 1978. *Theriogenology* 10:223.
8 Kiracofe, G. H., et al. 1978. *Journal of Animal Science* 47 (Suppl. 1) :36.
9 Kiser, T. E., et al. 1980. *Theriogenology* 13:381.
10 Mares, S. E., et al. 1977. *Journal of Animal Science* 45 (Suppl. 1) :185.

Urbana, Illinois September, 1982

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. WILLIAM R. OSCHWALD, Director, Cooperative Extension Service, University of Illinois at Urbana-Champaign.